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IN JUNIOR HIGH SCHOOL GIRLS

by

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled SELECTED MEASURES OF PHYSICAL FITNESS IN JUNIOR HIGH SCHOOL GIRLS submitted by CANDICE B. STASYNEC in partial fulfilment of the requirements for the degree of MASTER OF SCIENCE IN PHYSICAL EDUCATION.

ABSTRACT

The study was designed to investigate the reliability of the PWC 170 test. By accepting the modified Sjostrand Physical Work Capacity 170 test as the criterion measure of work capacity, a further problem was to study the relationship of the PWC 170 test to the C.A.H.P.E.R. Fitness Performance tests, to the 12 minute run test and to percent body fat.

The sample totaled eighty-seven adolescent females who participated in physical education classes at Spruce Grove Composite High School, Spruce Grove, Alberta. Participants performed two trials of the Sjostrand test, the C.A.H.P.E.R. Fitness Performance test and the twelve minute distance run. In addition, four skinfold sites were measured in order to estimate body fat.

Results indicated significant correlations at the .05 level of confidence between trial one and trial two of the criterion measure, between the twelve minute run test and the criterion test and between percent fat and the criterion test. Significant correlations were also found between five items of the C.A.H.P.E.R. performance test and the criterion measure.

On the basis to the results of this study it was concluded that the Physical Work Capacity 170 test was a

reliable measurement on adolescent females. It was also concluded that the twelve minute distance test was a good measure of physical work capacity in young girls.

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CHAPTER I

INTRODUCTION

"In recent years, Physical Education programs have reflected a renewed interest in the development of physical fitness" (25:86). The improvement of fitness status has become an accepted objective of physical education programs (13). Most exercise physiologists agree that the measurement of maximum oxygen intake ($M\dot{V}O_2$) is the best single measure of physical fitness (12,24). However, it is also equally accepted that $M\dot{V}O_2$ testing is not practical in the field situation or in large populations. As a result, numerous field tests have been developed to assess physical fitness (13). Given the assortment of tests, the physical educator must identify those measures that are best suited to his or her needs. The physical education teacher must be able to recognize the strengths and weaknesses of the measurement. Two important factors in test selection are reliability and validity.

The measure of reliability is an index of the liklihood that a test or measure, if administered once, would yield the same results if re-administered. According to Ferguson (20), the four methods to obtain the reliability coefficient include the test-retest method, parallel-form, split-half and the internal consistency method. The test-retest method is commonly used in exercise physiology and was the method

chosen for this study. In this case, the same measuring instrument or test is given to the same individual on two occasions. The duration of the interval separating the two trials is critical and should always be indicated. If for example, the interval is too short, the individual may not have fully recovered from an exercise bout. If, on the other hand, the interval is too long, a training effect bias could influence the retest score and thus alter the reliability correlation coefficient.

The degree of validity of a test indicates whether the test measures what it was intended to measure (20). Some tests will not measure what they should, while other tests will measure characteristics other than those intended. Of the four types of validity, namely, face, predictive, concurrent and construct, concurrent validity is most applicable to this study. In developing a new test, the investigator will compare it against an established measure to determine the concurrent validity. A high positive correlation between the scores will indicate that the two tests measure, to a large degree, the same thing.

In the present study, three standard tests of physical fitness have been investigated. The Physical Work Capacity 170 test (PWC 170) was selected as the criterion measure. The correlation of PWC 170 with $M\dot{V}O_2$ tests has been shown to be substantial and is considered a good field measure of fitness (12). The other two tests examined were the Canadian Association for Health, Physical Education and Recreation

(C.A.H.P.E.R.) Fitness-Performance test and the Cooper twelve minute walk/run test.

Problem

It was the purpose of this study to examine the reliability of one selected test of physical work capacity and the validity of two other tests of fitness in females aged 13 to 15 years inclusive.

Subsidiary Problems

In addition, the following subsidary problems were investigated:

1. The physical work capacity and physical fitness of junior high school females.

2. The relationship of percent body fat to physical work capacity in junior high school females.

Hypotheses

The following null hypotheses were tested for significance at the .05 level of confidence:

1. There was no significant relationship between the first and second trial of the Physical Work Capacity 170 Test.

2. There was no significant relationship between each of the C.A.H.P.E.R. items, namely sit-ups, long jump, shuttle run, flexed arm hang, 50 yard run and 300 yard run and Physical Work Capacity 170.

3. There was no significant relationship between the 12 minute run and Physical Work Capacity 170.

4. There was no significant relationship between percent fat and Physical Work Capacity 170.

Justification

Physical educators are often concerned with the measurement of physical fitness in various populations. Much of the research examining the reliability and validity of fitness tests has been centered on adult and/or male populations. Significant correlations between the three selected tests would demonstrate the reliability and validity of these measures in adolescent females.

Limitations

1. Temperature and humidity could not be controlled.

2. Although an attempt was made to ensure that all subjects

were in a resting state prior to testing, this was not controlled for each subject.

3. The C.A.H.P.E.R. test, excluding the 50 yard and 300 yard runs, was administered by the physical educator at Spruce Grove three weeks prior to the other test items.

Delimitations

The study was delimited to include only females, aged 13, 14 and 15 years, who were students at Spruce Grove Composite High School, Spruce Grove, Alberta.

Definition of Terms

1. Maximal oxygen consumption ($M\dot{V}O_2$) is the maximum amount of oxygen that an individual can utilize per minute. $M\dot{V}O_2$ is considered by many physiologists to be the best single measure of physical fitness. $M\dot{V}O_2$ values may be expressed in two forms; first as litres of oxygen consumed per minute (l/min) or second, and more commonly, as millilitres per kilogram of body weight per minute (ml/kg/min) (17).

2. Physical Work Capacity 170 (PWC 170) is defined as the power output, in kilopond meters (kpm), that an individual can accomplish at a heart rate of 170 beats per minute. The PWC 170 test is based on the linear relationship between

heart rate and power output (12). Work capacity scores may be expressed in two forms; first, as PWC 170 in total kilopond meters per minute (kpm/min) or second, as PWC 170/kg, in kilopond meters per kilogram of body weight per minute (kpm/kg/min).

3. Kilopond metre (kpm) is the force which acts on a one kilogram mass at the normal acceleration of gravity for one meter per second (2).

CHAPTER II

REVIEW OF RELATED LITERATURE

I Physical Work Capacity 170 Test

"Maximal oxygen intake is considered by most physiologists to be the best single measure of an individual's capacity to perform prolonged physical work" (24:13). Maximal testing, however, is often practical only in the laboratory setting. Tests of this nature are often complex, time consuming and impractical in the field situaticn. Alternatively, a number of submaximal tests have been developed which are kncwn to correlate significantly with maximal oxygen intake (25). The criterion, submaximal test selected for this study was the Physical Work Capacity Test at a heart rate of 170 beats per minute.

The PWC 170 test has undergone numerous revisions throughout the years. In 1947, Sjostrand (34) first reported its use on twenty ore smelting workers. At this time, three to four workloads of ten minutes each were employed and subjects pedalled until a heart rate of 175 beats was obtained. One year later, Wahlund (35) decreased the time of the work periods to six and one-half minutes each and set the maximum heart rate to 170 beats per minute. In 1949, Kjellberg (26) and workers further modified the PWC 170 bicycle test to include three six minute workloads. From

this time on the test became commonly known as the modified Sjostrand PWC 170 test.

The next major revision occurred in 1966. Howell and Macnab (24), as principal investigators for the Canadian Association for Health, Physical Education and Recreation , studied the physical working capacity of Canadian school children. In the pilot study, the modified Sjostrand test was used. Following the initial experimentation, the investigators shortened the test to twelve minutes by using three four-minute work periods. A total of 2107 children between the ages of 7 and 17 years were assessed. The data was entered onto data cards and later transfered to IBM computer cards. Calculation of the regression line was done by the "least square" method and the equation was then solved for a heart rate of 170. From these results normative tables in the form of percentiles were established according to sex by body weight, body type or build was not accounted for within age groups. The average scores for females, aged 13 to 15 years inclusive, were reported as follows:

Age	Number	PWC 170 (kpm)	PWC 170/kg (kpm)	
13	89	450.5±144.6	9.17±2.75	
14	81	436.8±127.0	8.51±2.65	
15	91	443.8±135.3	8.27±2.37	(24)

When investigating normal California school children,

Adams et al (1), also used a modified Sjostrand test. Two hundred and forty-three children, ages 6 to 14 years served as subjects. The mean working capacity for 13 year old females (n=20) was 564 kpm/min and for 14 year old girls (n=21) the value was 542 kpm/min. Adams calculated the PWC 170 scores on graph paper and did not correct for pedal revolutions.

In 1963, Cumming and Cumming (9) examined the physical working capacity of two hundred Winnipeg school children aged 6 to 16 years. Subjects pedalled for a total of eighteen minutes at three different resistance loads. The investigators did not correct for pedal revolutions. The PWC 170 score was determined by plotting workload versus pulse rate on graph paper. The mean PWC 170 for 13 year old females (n=5) was 336 kpm/min; for 14 year olds (n=5) it was 497 kpm/min and for the 15 year old girls (n=5) the mean score was 489 kpm/min.

<u>Reliability and Validity Studies of PWC 170</u>

In 1962, Borg and Dahlstrom (4) conducted a study to examine the reliability and validity of the modified Sjostrand bicycle test. Reliability was determined by two methods, the intra-test consistency method and the test-retest method. Intra-test reliability consisted of correlating the pulse rates with each other after 2, 4 and 6 minute periods of work. The highest correlations between

pulse rates were found from 4 to 6 minutes (r=0.97 and r=0.98, respectively). The retest correlation for the PWC 170 was r=0.76. The authors indicated that this was lower than other studies had reported and attributed it to the year long interval separating trial one and trial two. Borg and Dahlstrom also investigated the validity of the modified Sjostrand test by comparing PWC 170 scores to results in a 20 mile skiing race. The highest validity correlation coefficient obtained was r=0.54. It should be noted that the authors did not specify which of the two PWC 170 tests were used for the validation. In addition, the skiing race took place seven months after the first bicycle test and one month prior to the second test.

In 1965, Zahar (37), in his unpublished Master's thesis, investigated the reliability of the modified Sjostrand work test. The sample consisted of thirty-eight high school males enrolled in physical education classes. A PWC 170 test was administered to each subject, once a week for six weeks. Following this, the test-retest reliability coefficients were determined. Coefficients ranged from 0.89 for the first and second tests to 0.95 between the fifth and sixth tests. Zahar reported that the difference between the first and second trial were not statistically significant at the .05 level. The author also indicated that although improvement does occur from the first to the sixth trial, he could not be certain of the cause. His conclusion was that the Sjostrand test was a highly reliable measure of physical

work capacity .

Burke (5) conducted a project to assess the validity of selected labotratory and field measures of physical working capacity. Forty-four male students aged 17 to 30 years served as subjects. Included in the test battery was a maximal oxygen uptake treadmill test and the PWC 170 test. The correlation coefficient obtained between the two tests was 0.58. Burke suggested two possibilities for the rather low correlation. One possibility was that Americans were not yet accustomed to bicycling and the second was the existence of individual differences which adversely effected the linear relationship between $M\dot{V}O_2$ and heart rate.

In 1969, Fedoruk (19) conducted a study which examined the reliability of PWC 170 on twenty-four 18 year old females. Among the test battery, the modified Sjostrand test was administered on two occasions, on the same day. The correlation coefficient was found to be r=0.75 when work capacity was expressed in kpm/min. With body weight factored out (kpm/kg/min), the reliability coefficient decreased to r=0.70. Fedoruk indicated that the lowering of the coefficient was evidence of the influence of body weight on work capacity values.

Studies Relating PWC 170 to C.A.H.P.E.R. Performance Test

One of the few pieces of research relating PWC 170 and the C.A.H.P.E.R. Fitness Performance test was conducted in

1967 by Cumming and Keynes (11). The investigators studied the relationship of the C.A.H.P.E.R. performance scores to PWC 170, MvO and anthropometric measures (height, weight and surface area). The sample involved four hundred and ninety seven normal Winnipeg school children aged 6 to 18 years. Of this number, two hundred and forty-seven were females, fifty of whom were 13 to 15 years of age. Of all the data collected on the female group, log surface area showed the highest correlation with PWC 170 (r=0.63). The correlation coefficients between PWC 170 and the C.A.H.P.E.R. items were as follows: sit-ups r=0.27, broad jump r=0.39, shuttle run r=0.30, arm hang r=0.10, 50 yard run r=0.30 and the 300 yard run r=0.32. From these results, it appeared that the C.A.H.P.E.R. items accounted for only 10 to 20% of the variability of the working capacity of young females. Cumming concluded that success in the C.A.H.P.E.R. tests was size dependent and that these tests were of little use in predicting work capacity.

<u>Studies Relating PWC 170 to the 12 Minute Walk/Run</u>

Although there are numerous studies relating the 12 minute walk/run test to $M\dot{V}O_2$ (7,14,28) little research has been conducted showing the relationship of the distance run test to PWC 170.

In the previously mentioned study of Burke (5), male college students were also tested on the PWC 170 and the 12

minute run. These were only two of the fifteen laboratory and field measures that were studied. The correlation coefficient calculated for these two items was r=0.60.

Cumming (33) indicated that he had found significant correlations between the PWC 170 and the 12 minute distance in junior and senior high school youths. For females, aged 13 to 17 years, enrolled in a track and field camp (n=61), the correlation was 0.45. For junior and senior high school girls of the same age (n=28) r=0.57. Both values were significant at the .01 level of confidence, indicating a substantial positive relationship between the PWC 170 and the twelve minute distance run.

II The Canadian Association of Health, Physical Education and Recreation Fitness Performance Test

In 1964, the Canadian Association of Health, Physical Education and Recreation (C.A.H.P.E.R.) organized a standard fitness performance test for Canadian youth ages 7 to 17 years (23). A representative sample of 500 girls and 500 boys in each age group was selected from across the country. Each child was assessed on six items, namely, shuttle run, speed sit-ups, standing long jump, flexed arm hang, 50 yard dash and the 300 yard run. A description of the six performance items is found in Appendix C. Upon completion of this study, normative tables, in the form of percentiles, were established to provide "boys and girls with an exact, objective measure of fitness..." (23:20).

In 1961, Gross and Casciani (21) studied the value of age, height and weight as classification indices in the performance of the American Association of Health, Physical Education and Recreation (A.A.H.P.E.R.). Data was obtained on 13,000 students, 2,695 of whom were junior high school girls aged 11 to 15 1/2 years. Multiple correlations between the combination of factors of age, height and weight and the seven fitness tests ranged from 0.14 to 0.24. The investigators concluded that these three factors were of little value for classification purposes. Their

recommendation was that "the senior high school girls, the junior high school girls, the senior high school boys and the junior high school boys, respectively, may be considered as a homogenous group with respect to the effect of age, height and weight on certain fitness measures..." (21:57).

In 1962, Espenschade (18) re-evaluated the relationships between physical performances of school children and age, height and weight. Of a total of 7600 children tested (10 to 18 years old), one-half were female. Simple and multiple correlations were computed and the results indicated that although height and weight varied markedly from certain types of performances to others, significant increases occurred in many events by age. Espenschade suggested that boys and younger girls should be classified according to age, at least, for fitness performance type tests.

III The Twelve Minute Walk/Run Test

According to Cooper (7), "the more commonly accepted definition (of physical fitness) implies the existence of adequate pulmonary reserves" (7:636). In 1968, Cooper (7) developed the 12 minute walk/run field test to assess this aspect of physical fitness.

In a preliminary communication, Cooper presented data on 115 U.S. Air Force males. Each subject had been tested on the treadmill oxygen comsumption test and then on the 12 minute field performance test. The correlation coefficient of the field to laboratory test was 0.90, indicating a significantly high relationship between the two measures. From these results, it appeared that the 12 minute test was a valid measure of $M\dot{V}O_2$. Cooper also repeated the distance run test on all subjects but did not report the reliability coefficient. He simply stated that after a four day interval the results were comparable.

Following the work done by Cooper, there have been numerous studies reporting the use of the 12 minute run (13,14,25). However, few of these deal with young females. Doolittle and Bigbee (14) investigated the reliability and validity of Cooper's run on 153 grade nine males. The test-retest correlation was reported as 0.94, following a four day interval. The relationship between $M\dot{V}O_2$ (on 9 of the

males) and the run was r=0.62. Doolittle and Bigbee stated that for young males, the 12 minute run was a highly reliable and valid test of cardiorespiratory fitness.

In 1971, Maksud and Coutts (28) reported similar findings on 11 to 14 year old boys. The test-retest reliability coefficient was 0.92 and the correlation between $M\dot{V}O_2$ and the run was 0.65.

In contrast to these two studies, Wanamaker (36), in 1970 reported validity coefficients of 0.22 to 0.53 between $M\dot{V}O_2$ and the 12 minute run in ninety-six males, 18 to 23 years of age. In this study, $M\dot{V}O_2$ was determined by a discontinuous treadmill test. The reliability correlation ranged from 0.82 to 0.95. Wanamaker suggested that although the 12 minute test was reliable, it was not an effective predictor of $M\dot{V}O_2$.

Cumming (3) reported the validity of the distance run in young females. In twenty-seven school girls 8 to 16 years of age, the correlation of the 12 minute run to $M\dot{V}O_2$ was 0.74. This coefficient increased to 0.87 for ten girl athletes aged 12 to 17 years. From these results, Cumming stated that the 12 minute run test was just as good, if not better, than the bicycle ergometer test in predicting $M\dot{V}O_2$.

In 1972, Jackson and Coleman (25) investigated the validity of distance run tests in elementary school children. Construct validation was measured in five runs-the 50 yard dash and the 3, 6, 9 and 12 minute runs. The subjects were 866 boys and 803 girls, aged 10 to 12 years.

Factor analysis indicated that the 9 minute and the 12 minute runs were the most suitable to measure distance running ability. Next, concurrent validation was measured on the 9 minute and 12 minute runs. Maximal oxygen intake was measured on twenty-two boys and twenty-five girls. Pearson-product moment correlations were calculated to estimate the relationship between the runs and $M\dot{v}O_2$. Zero-order correlations for the girls were 0.71 for $M\dot{v}O_2$ and the 9 minute run; 0.71 for $M\dot{v}O_2$ and the 12 minute run and 0.86 for the 9 minute and 12 minute runs. All correlations were significantly different frcm zero. The investigators also showed that with the 9 minute run held constant, the correlation between $M\dot{v}O_2$ and the 12 minute run was not significant. Therfore, the authcrs reccmmended that because running the additional three minutes did not add to the concurrent validty, perhaps the 9 minute run should replace the 12 minute test.

IV Body Fat in Adolescent Females

There have been several investigations concerned with the body composition of adolescent females. In 1966, Hampton and co-workers (22) reported a longitudinal evalution of gross body composition and body conformation in a teenage population. Included in the study were 519 females whose average age was 14.5 years and 452 females whose mean age was 15.2 years. Lean body weight was determined anthropometrically on all subjects. On a smaller, sub-sample, lean body weight was also calculated by two other methods, by specific gravity and radioactive potassium. Anthropometric results showed that the average body fat of the 14.5 year old group was 16.4% while mean body fat for the older group was 16.8%. The investigators indicated, however, that the mean lean body weight determined by anthropometric measures (47.9 kg) was substantially higher, approximately 6.0 kg, than the values obtained by the other two methods.

In the study of Durnin and Rahaman (16), the body composition of eighty-six adolescents was assessed by two methods. Skinfold thickness was measured at four sites, the mid-biceps, mid-triceps, sub-scapular and suprailiac. Body density was determined by hydrostatic weighing. The correlation between the two methods, in adolescent girls,

was r=-0.78. This was significant at the 0.001 level. The mean fat percentage, derived from measurements of body density was 24.0±4.9%. For practical use, Durnin computed the regression equation for the prediction of body density from the log sum of skinfold thickness from all four sites. For adolescent females the equation is:

$$Y=1.1369-0.0598X \qquad S.E.\pm0.0081.$$

Inserting this figure of body density, into the Siri equation (16) per cent fat may be calculated as follows:

$$\text{Fat } (\%) = [(4.95/\text{density}) - 4.5] \times 100.$$

In 1975, Drinkwater et al (15) reported on the aerobic power of 123 females, ages 10 to 68. Body fat was estimated by hydrostatic weighing or from skinfold measurements. The predicted fat for the 13 year old girls (n=11) was 16.1±1.5 % and for the 14 year olds (n=10), the estimated fat was 21.3±3.9 % of body weight.

Studies Relating Body Composition and Work Capacity

In 1955, Miller and Blyth (29) investigated the effects of body composition on work capacity. Thirty males, aged 19 to 28 years performed submaximal exercise on the treadmill. Percent fat was estimated from densiometrically determined specific gravity. The correlation between oxygen uptake (ml/kg/min) and percent fat was r=-0.23, which was not significant at the .01 level of confidence. The author increases, the exercise oxygen requirement per unit of lean

body mass also increases.

Buskirk and Taylor (6), in 1957, found a correlation of .63 between body weight and $M\dot{V}O_2$ and a correlation of .85 between fat-free weight and $M\dot{V}O_2$ in male subjects, aged 18 to 29 years. The correlation of percent fat and $M\dot{V}O_2$ was not calculated. From the results, the investigators concluded that although the presence of excess fat does not significantly influence the capacity of the cardiovascular system in exhausting work, excess fat will increase the oxygen cost and therefore increases the cardiovascular load during submaximal work.

In 1968, Neill (30) investigated the relationship of estimates of body composition and measures of maximal and submaximal work capacity. Included in the study were twenty-four females, the average age being 18.7 years. The Sjostrand PWC 170 test was selected as one of the measures of submaximal work capacity. Body composition was estimated by hydrostatic weighing. The mean body fat for the females was 23.4±4.5 %. The correlation of PWC 170 and percent fat was r=-0.41. This was significant at the .05 level. There was, however, no significant difference in the correlations of PWC 170 with total body weight (r=0.44) and PWC 170 with fat-free body weight (r=0.60). The author concluded, therefore, that in this study the amount of fat did not significantly influence the ability to perform submaximal work.

CHAPTER III

METHODS AND PROCEDURES

Subjects

A total of eighty-seven healthy females aged 13 to 15 years of age, inclusive, participated in this investigation. This number represented the total number of junior high school girls who were actively involved in the physical education classes at Spruce Grove Composite High School, Spruce Grove, Alberta. However, due to absenteeism, all subjects did not complete every item of the test battery. Testing, with the exception of the shuttle run, sit-ups, flexed arm hang and standing long jump, was conducted from 9:00 a.m. to 12 noon, Monday through Friday for a three week period, in March 1977. As the testing was considered part of the physical education curriculum, all healthy students were required to take the tests. Parental consent forms were therefore deemed unnecessary. All students wore the required attire of shorts, T-shirts and running shoes.

Testing Procedures

Anthropometric Measures

Height and weight were measured using a Decto-Medico scale. Subjects were measured in their gym clothing minus shoes. Skinfold measurements were taken at four sites: the

biceps, triceps, sub-scapular and suprailiac. This was in accordance with the method of Durnin and Rahman (16). A detailed description cf the anatomical location of each skinfold site is presented in Appendix B. Skinfolds were taken using Harpenden calipers and all measurements were taken on the right side of the body. The averages of three trials were recorded to the nearest one-tenth of a millimeter.

Physical Work Capacity Test

Physical Work Capacity at a heart rate of 170 beats per minute was determined by the method of Hcwell and MacNab (24). The Von Dobeln type of ergometer, manufactured by the Monark Company was utilized. Heart rate was measured by ascultation at the cardiac apex. A pedalling cadence of 60 complete revoluticns per minute was required. The rhythm was assisted with a standard laboratory metranome. Pedal revolutions were counted by an electric counter attached to the ergometer and were recorded at four minute intervals.

Each subject was tested twice on the PWC 170 with a two to three day interval between trials. Prior to the test, the subject was seated on the ergometer and the seat height was adjusted so that the leg was slightly flexed at the lowest point of the pedal travel. Three workloads of four minutes each were administered. For most of the subjects, the workloads used were 300 kpm, 450 kpm and 600 kpm. The workloads, for each subject, remained the same for both

trials. Details of the workloads are presented in Appendix E.

Twelve Minute Walk/Run

The Cooper 12 minute run was conducted indoors. One lap of the gymnasium measured 260 feet. Pylons were placed on the corners of the running track to ensure that the full distance was covered. Six to eight subjects were tested at one time. On the final lap, the distance from the starting line to where each subject finished was measured and recorded.

C.A.H.P.E.R. Performance Test

The C.A.H.P.E.R. performance test was conducted according to the format described in the C.A.H.P.E.R. Test Manual (23). The test consisted of 6 items, speed sit-ups, standing long jump, shuttle run, flexed arm hang, 50 yard run and 300 yard run. The shuttle run, sit-ups, flexed arm hang and standing long jump were administered by the Physical Education teacher three weeks earlier. The 50 yard and 300 yard runs were administered during the three week period in March, 1977. All test items were administered according to the procedures outlined in Appendix C. Details of the test items are presented in Appendix C.

Statistical Treatment

The range, means and standard deviations were computed for all parameters.

Accepting the first trial of the PWC 170 test as the criterion or dependent variable, estimates of validity of the independent variables, namely the C.A.H.P.E.R. Fitness Performance Test and the 12 minute run were investigated. Data obtained on 73 subjects was used in this segment of the study. Validity measures were determined using a stepwise linear regression as outlined in the *Statistical Package for the Social Sciences* Manual (31).

Reliability measures were determined between the two trials of the PWC 170 test using Pearson product moment correlations as outlined in Ferguson (20). A one-way analysis of variance was used to test for differences between age groups. A total of 79 subjects participated in the reliability portion of the present investigation.

CHAPTER IV

RESULTS AND DISCUSSION

Characteristics of Subjects

Grade 8 and 9 females, who were participants in the physical education classes at Spruce Grove Composite High School, Spruce Grove, Alberta, comprised the sample of subjects used in this study. Some of the physical characteristics of the subjects are presented in Table 4.1.

Table 4.1

Characteristics of Subjects

	Mean	Standard Deviation
Age (years)	13.7	± .7
Weight (kg)	53.9	±9.0
Height (cm)	160.5	±7.9
% Body Fat	25.1	±5.4

Physical Work Capacity

The mean values of PWC 170 and PWC 170/kg obtained in the present investigation and in other studies are presented in Table 4.2. In all cases, the Spruce Grove subjects attained the highest work capacity scores. The substantial differences between the C.A.H.P.E.R. (24) results and the

Table 4.2

Physical Work Capacity Values in
This and Other Studies

Study	Sex	Age(yrs)	PWC 170	PWC 170/kg
Adams(1961)	F	13	564.0	
		14	542.0	
Cumming(1963)	F	13	336.0	
		14	497.0	
		15	489.0	
C.A.H.P.E.R. (1966)	F	13	450.5±144.6	9.17±2.75
		14	436.8±127.0	8.51±2.88
		15	443.8±135.3	8.27±2.37
Spruce Grove (1977)	F	13(n=35)	582.2±133.1	11.29±2.42
		14(n=37)	588.2±146.1	11.16±2.88
		15(n= 7)	642.2± 82.4	11.48±1.90

results from the present study may be explained in several ways:

1. The C.A.H.P.E.R. sample was three times the size of the Spruce Grove sample. Therefore, the C.A.H.P.E.R. results may be considered to be more representative of the physical work capacity of adolescent females.

2. The C.A.H.P.E.R. study was conducted eleven years ago. From that time to the present, there has been a widespread campaign to promote health and physical fitness. It is possible that the superior Spruce Grove results reflect a trend toward better fitness levels.

3. The higher work capacity scores of the Spruce Grove

girls may be a consequence of the substantial emphasis placed on physical fitness in the physical education curriculum at the school.

The results of Adams (1) compare more favourably to the Spruce Grove scores, while Cumming (9) reports work capacity values that were substantially lower. In both studies, the number of subjects was less than the C.A.H.P.E.R. and Spruce Grove samples.

C.A.H.P.E.R. Fitness-Performance Test

The means and standard deviations of the C.A.H.P.E.R. tests in the Spruce Grove sample are presented in Table 4.3. The comparison of these results to the naticnal norms are presented graphically in Figures 1 through 6. The results indicate that the flexed arm hang (Fig.4) was the only item

Table 4.3

Results of the C.A.H.P.E.R. Fitness Performance Test for the Spruce Grove Sample

Item	13 years	14 years	15 years
Sit-ups	40 ± 7	44 ± 9	35 ± 3
Long Jump(ins)	66 ± 8	65 ± 8	64 ±11
Shuttle Run(sec)	11.7±0.7	11.7±0.9	12.0±1.4
Flexed Arm Hang(sec)	27 ±19	26 ±17	13 ±12
50 yard(sec)	8.0±0.7	8.1±0.7	8.4±1.2
300 yard(sec)	69 ± 5	68 ± 5	68 ± 2

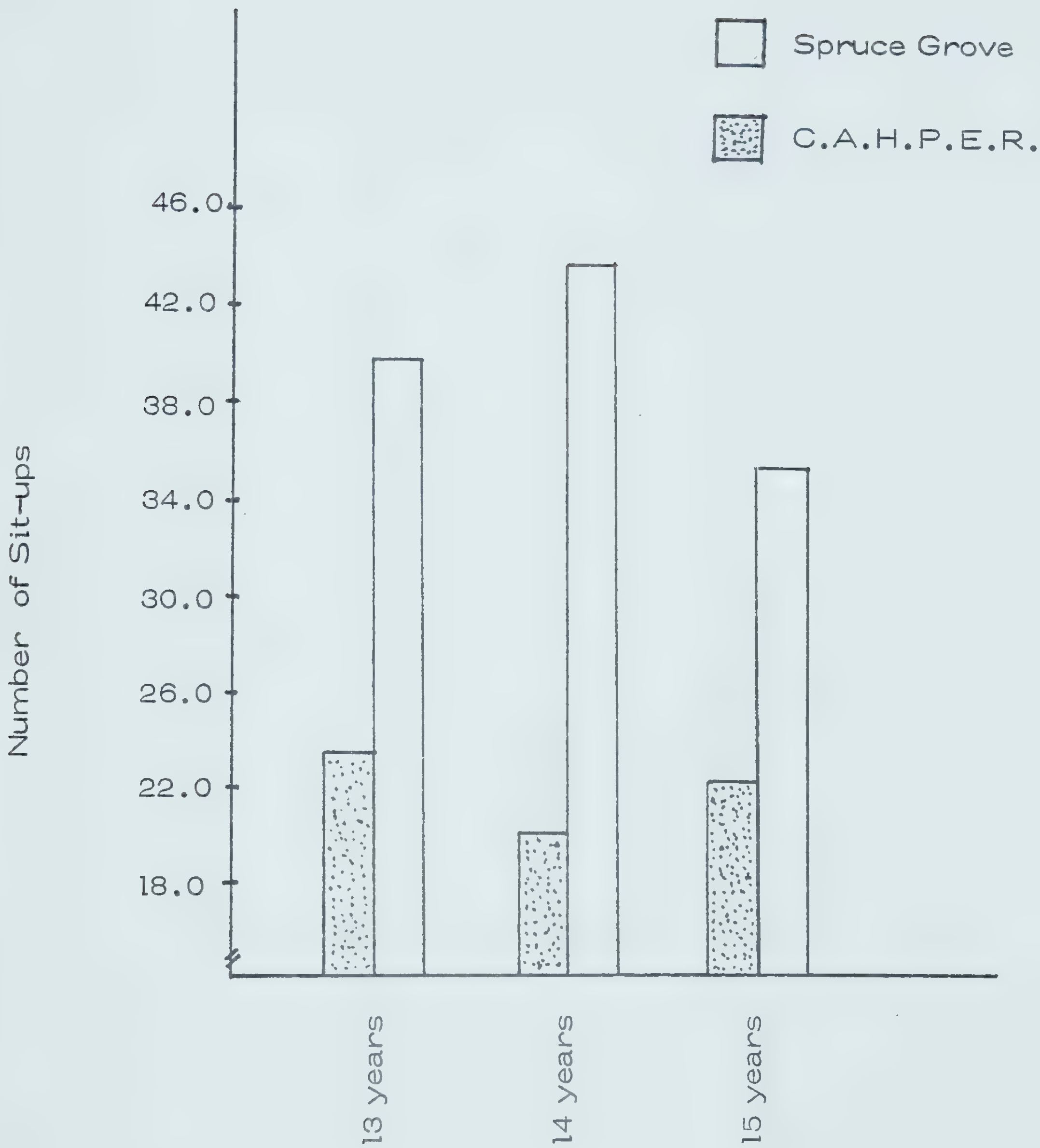

Figure 1

Mean Scores of Situps
Spruce Grove vs C.A.H.P.E.R.

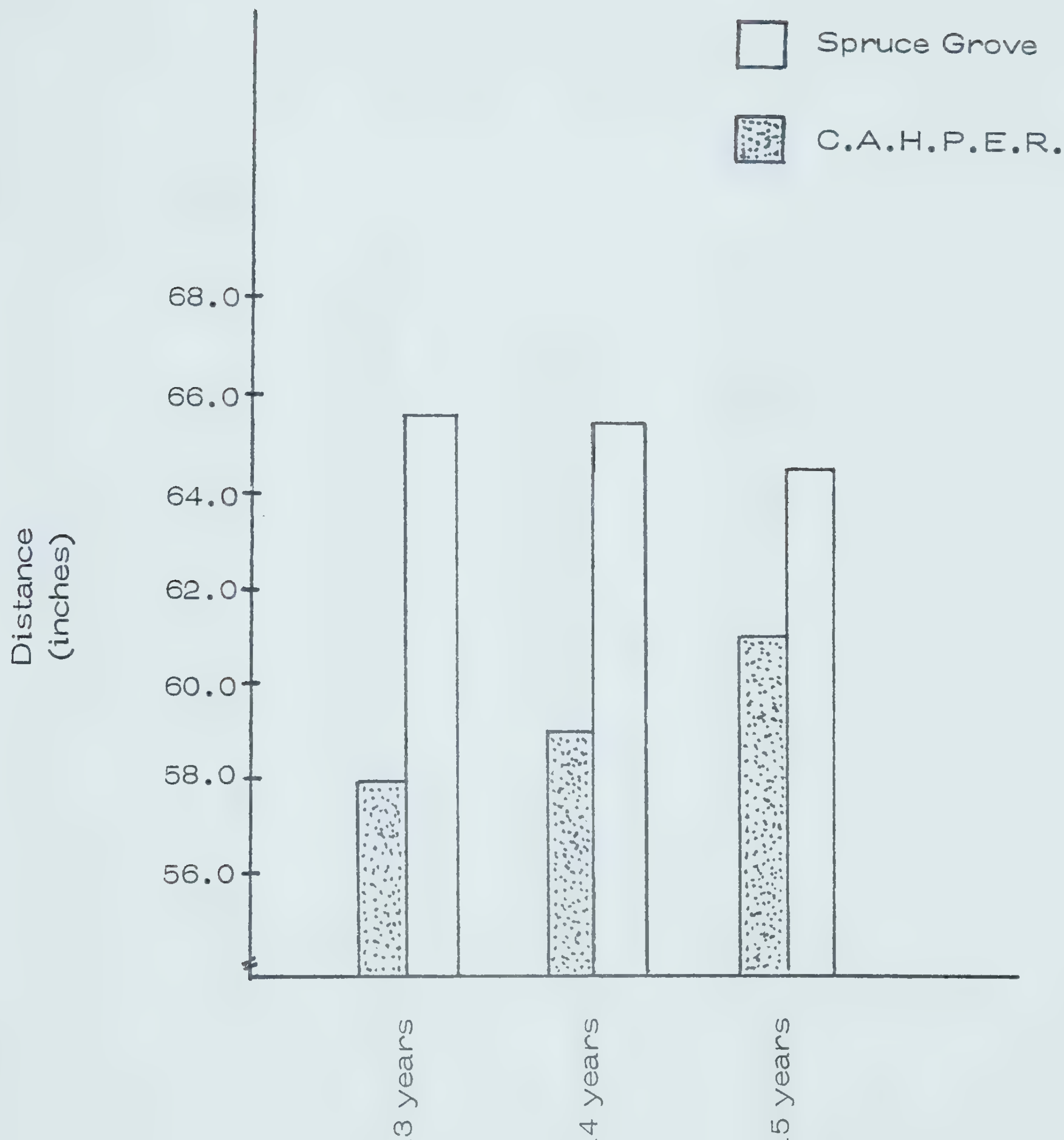

Figure 2

Mean Scores of Standing Long Jump
Spruce Grove vs C.A.H.P.E.R.

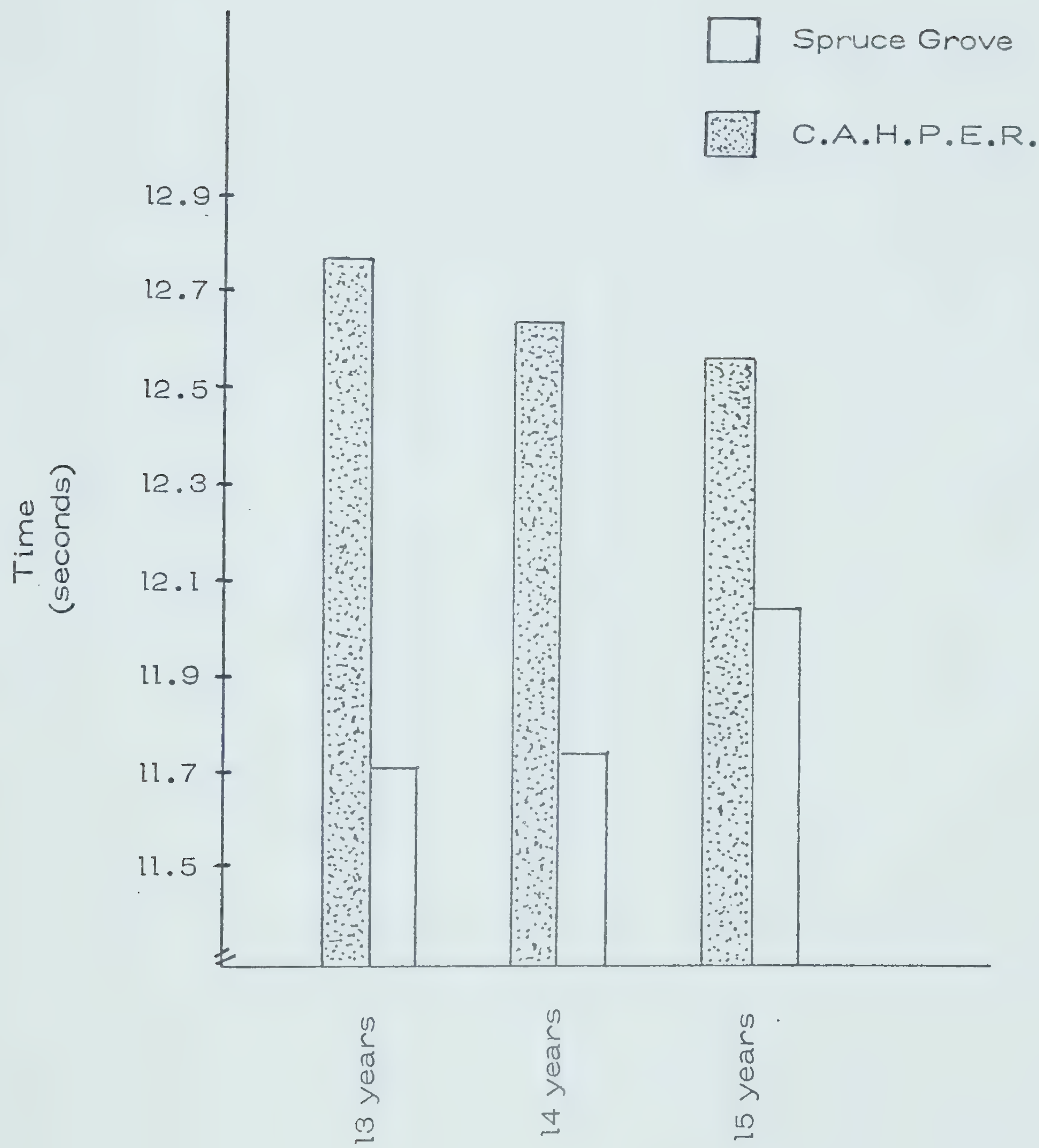

Figure 3

Mean Scores of Shuttle Run
Spruce Grove vs C.A.H.P.E.R.

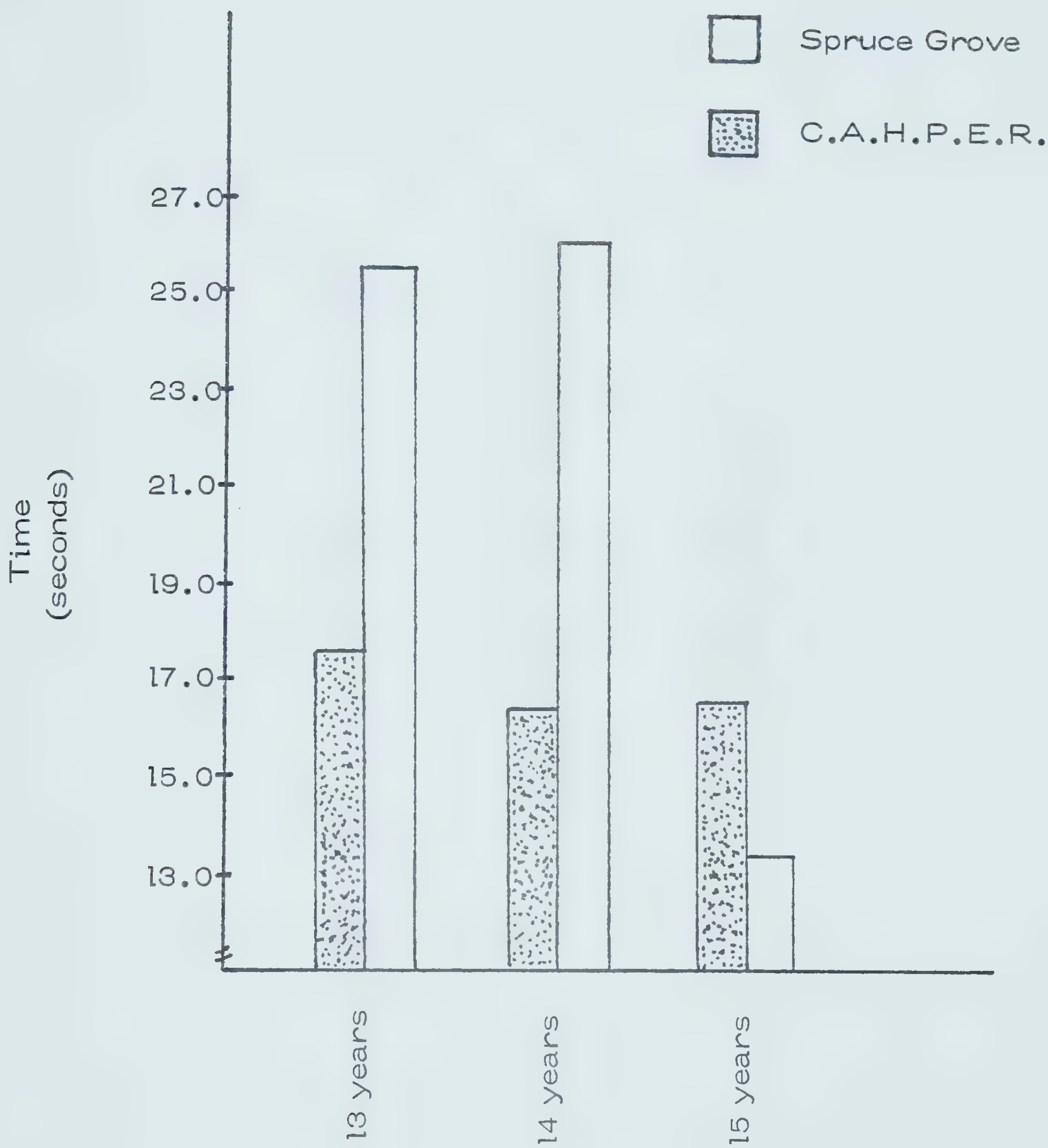

Figure 4

Mean Scores of Flexed Arm Hang
Spruce Grove vs C.A.H.P.E.R.

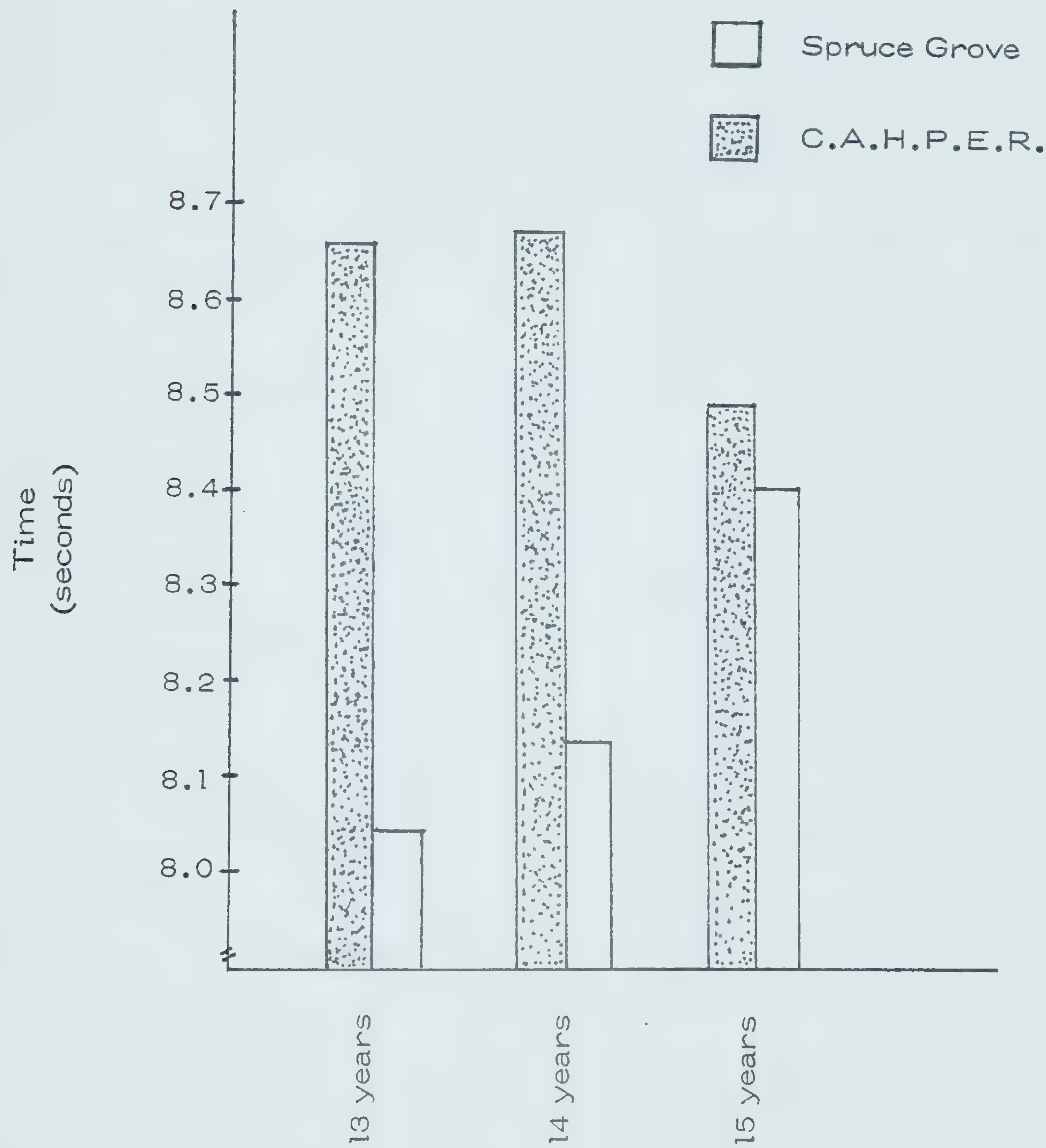

Figure 5

Mean Scores of 50 Yard Run
Spruce Grove vs C.A.H.P.E.R.

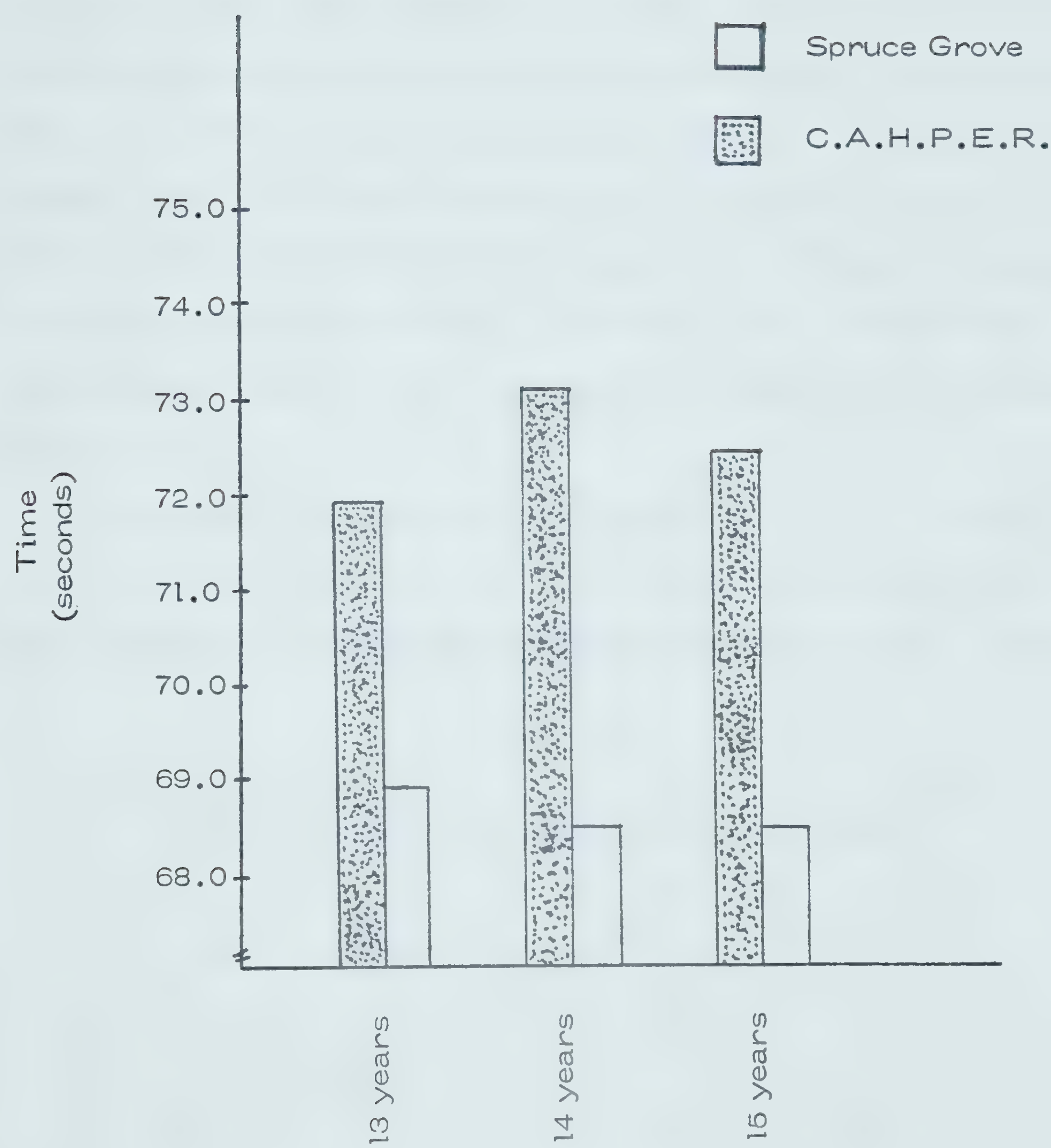

Figure 6

Mean Scores of 300 Yard Run
Spruce Grove vs C.A.H.P.E.R.

in which the Spruce Grove sample did not consistently outperform the C.A.H.P.E.R. sample. In the flexed arm hang the C.A.H.P.E.R. 15 year olds attained a mean value of 16.5±13.7 secs. while the mean duration for the Spruce Grove 15 year olds was 13.3±11.7 secs.. Once again, the C.A.H.P.E.R. sample was considerably larger (approximately 1057) than the Spruce Grove sample (73). This factor may account for the discrepancy in the results. However, it is also possible that because of repeated testings throughout the years, the Spruce Grove girls were more familar with the performance items and consequently obtained the superior scores.

The means and standard deviations of the C.A.H.P.E.R. tests obtained by Cumming (11) are presented in Table 4.4. When Cumming's results are compared to those of the present

Table 4.4

Results of the C.A.H.P.E.R. Fitness Performance Test Obtained by Cumming & Keynes (1967)

Item	13 years	14 years	15 years
Sit-ups	30 ± 9	34 ± 6	32 ±11
Long Jump(ins)	60 ±10	65 ± 8	68 ± 8
Shuttle Run(sec)	12 ± 1	12 ± 3	12 ± 1
Flexed Arm Hang(sec)	21 ± 20	18 ±14	24 ±18
50 Yard(sec)	8.3±0.9	8.1±0.4	8.2±0.7
300 Yard(sec)	70 ± 5	68 ± 6	69 ± 7

study, it can be seen that the 13 and 14 year olds from Spruce Grove attained slightly higher scores in the majority

of items. The 15 year olds in the Cumming study were superior to their Spruce Grove couterparts in the long jump (68±8 in), flexed arm hang (24±18 sec) and in the 50 yard dash (8.2±0.7 sec). However, overall, the results of the Cumming study and those obtained in the present study are in closer agreement than the results from C.A.H.P.E.R.. The similarity in scores may be due to the sample sizes. As previously mentioned, the C.A.H.P.E.R. survey involved over 1,000 subjects while Cumming & Keynes studied 50 females as compared to the 73 subjects used in the present study.

Twelve Minute Walk/Run

The mean results of the 12 minute walk/run obtained in the present study are presented in Table 4.5. It would

Table 4.5

Results of the Twelve Minute Walk/Run
for the Spruce Grove Sample

Age (years)		Distance (miles)
13	n=30	1.19±.13
14	n=36	1.22±.14
15	n=7	1.21±.21

appear, in this sample, that the age factor had little effect on running distance. Jackson & Coleman (25) reported a mean distance of 1.28±.16 miles in 25 eleven year old girls. This is slightly higher than the results of the

present investigation and may be due to the younger sample used by Jackson.

Reliability of the Physical Work Capacity 170 Test

The Physical Work Capacity 170 Test was repeated on two separate occasions on 79 females. The average test-retest interval was three days, the range was two to six days. The mean scores, obtained in the present investigation are presented in Table 4.6. The correlation coefficent for work capacity expressed in kpm/min was $r=0.74$, which was a

Table 4.6

Test-Retest Scores of Physical Work Capacity 170 Tests

Trial	PWC 170 (kpm/min)	PWC 170/kg (kpm/kg/min)
1	590.5±134.4	11.23±2.56
2	593.8±119.2	11.24±2.32

significant correlation ($p \leq 0.001$). When the mean work capacity score is expressed as kpm/kg/min the reliability coefficient was $r=0.74$, which was also significant ($p \leq 0.001$). A one-way analysis of variance indicated that there were no significant differences between the subject factors (age) or within the subject factcrs (trial 1 and trial 2). The analysis of variance table is presented in Appendix G. The results obtained in the Spruce Grove sample

are similar to the results of Fedoruk (19) and Borg and Dahlstrom (4). In the present study, there was a slight decrease in the reliability coefficient when the work capacity scores were expressed as kpm/kg/min. This is consistent with those reported by Fedoruk. Zahar (37) found reliability coefficients between 0.89 and 0.95 on a male population. The test-retest interval was one week. The higher coefficients may reflect a more highly controlled testing situation. In the present investigation, neither the time of the day that the test was re-administered nor the subjects' pre-test activity could be controlled. This may account for the discrepancy in the coefficients reported by Zahar (37).

Correlation of C.A.H.P.E.R. Fitness Performance Tests to Physical Work Capacity

The correlation coefficients of physical work capacity (kpm/min. and kpm/kg/min.) with the anthropometric measures and the C.A.H.P.E.R. items are presented in Tables 4.7 and 4.8. Expressed in kpm/min., height and weight showed the highest correlation with physical work capacity. Both correlations were significant ($p \leq 0.01$). In Table 4.8, with body weight factored out, the 300 and 50 yard run showed the highest positive relationship with PWC 170/kg. The correlations were both $r=0.42$. This was followed by the flexed arm hang ($r=0.40$), sit-ups($r=0.35$) and long jump

Table 4.7

Correlation Coefficients of C.A.H.P.E.R. Tests to the Physical Work Capacity (Kpm/min)

Variable	Coefficient	
Height	0.33	*
Weight	0.36	*
% Fat	-0.01	
Sit-ups	0.21	
Long Jump	0.22	
Shuttle Run	-0.18	
Flexed Arm Hang	0.12	
50 yard	-0.31	*
300 yard	-0.39	*

* significant ($p \leq 0.01$)

Table 4.8

Correlation Coefficients of C.A.H.P.E.R. Tests to Physical Work Capacity (Kpm/kg/min.)

Variable	Coefficient	
Height	0.08	
Weight	-0.30	*
% Fat	-0.44	*
Sit-ups	0.35	*
Long Jump	-0.33	*
Shuttle Run	-0.17	
Flexed Arm Hang	0.40	*
50 yard	-0.42	*
300 yard	-0.42	*

* significant ($p \leq 0.01$)

(0.33). All correlations were significant ($p \leq 0.01$).

The correlation coefficients of PWC 170/kg versus C.A.H.P.E.R., obtained by Cumming and Keynes (11), are presented in Table 4.9. The correlations of PWC 170/kg with height (.57) and weight (.61) were considerably larger than

Table 4.9

Correlation Coefficients of C.A.H.P.E.R. Tests
to Physical Work Capacity (kpm/kg/min)
Cumming and Keynes

Variable	Coefficient
Height	.57
Weight	.61
Sit-ups	.27
Long Jump	.39
Shuttle Run	.30
Flexed Arm Hang	.10
50 yard	.30
300 yard	.32

the values obtained in the present study. Cumming also reported higher correlations for the long jump (.39) and the shuttle run (.30). In the Spruce Grove sample, the long jump showed a correlation of r=0.22 with physical work capacity, while the correlation coefficient obtained for the shuttle run was r=0.18. The variation in correlations obtained by Cumming and those found in the Spruce Grove study may be reflective of the more homogeneous sample used in the present investigation. Whereas the age range was only three years in the Spruce Grove group, Cumming's sample included females whose ages were 6 to 18 years. This factor, combined with the larger sample used by Cumming and Keynes could account for the variations in the correlation coefficients. Cumming stated that the C.A.H.P.E.R. performance tests explained only 10 to 20 % of the commonality of the working capacity of girls (11). The results from the present investigation indicated that the C.A.H.P.E.R. tests explained 3 to 17 % of the commonality in the physical work capacity scores. The

results would indicate that there is little relationship between the C.A.H.P.E.R. Fitness Performance Tests and physical work capacity in junior high school girls.

<u>Correlation of Twelve Minute Walk/Run with Physical Work Capacity</u>

The correlation coefficient of the 12 minute walk/run to physical work capacity, expressed as kpm/min, was $r=0.37$. Factoring out body weight, the correlation rose to $r=.57$. Both values were significant ($p \leq 0.01$). The findings of this investigation are consistent with the results of Burke (5) and Cumming (3). Reporting on male college students, Burke found that the correlation between the 12 minute run and PWC 170 (kpm/kg/min) was 0.60. Cumming reported a correlation of 0.45 between the distance run and PWC 170 (kpm/kg/min) in female track and field athletes and a value of $r=0.57$ in normal junior and senior high school girls.

Previous investigations have shown the 12 minute run to be a reliable test (7,14,28). From the results of this and other studies (3,25,36) it wculd appear that the 12 minute walk/run is a valid measure of work capacity in adolescent females. Reasearch by Jackson and Coleman (25) recommended that a 9 minute run should be substituted for the standard 12 minute test. The investigators showed that the 9 and 12 minute tests had the same ccrrelaticn coefficient (0.71) with $M\dot{V}O_2$, and that the ccrrelaticn coefficient between the

two runs was 0.86. It would seem justified then, that the 12 minute walk/run be revised to a 9 minute distance run test.

Body Composition Estimates

The findings of the present investigation, as well as the results from previous studies, are presented in Table 4.10. The Spruce Grove sample appears to have an overall

Table 4.10

Body Composition Estimates Obtained in This and Other Studies

Study	Age (years)	% Fat
Hampton (1966)	14 15	16.4 % 16.8 %
Durnin (1967)	13-16	24.0 ± 4.9 %
Neill (1968)	18	23.4 ± 4.5 %
Drinkwater (1975)	13 14	16.1 ± 1.5 % 21.3 ± 3.9 %
Spruce Grove (1977)	13 (n=30) 14 (n=36) 15 (n= 7)	25.2 ± 5.0 % 24.4 ± 5.9 % 28.7 ± 1.7 %

higher percentage of body fat than the values reported in previous investigation. The results obtained by Neill (30) and Durnin (16) are comparable to those reported in the present study. In the present study, the Durnin (16) method was used to estimate body fat. It was therefore anticipated that the results would be similar to those of Durnin.

Hampton (22), however, reported substantially lower figures in 13 and 14 year old girls. The data was obtained 11 years prior to the Spruce Grove survey and all the subjects were residents of California. In addition, the method Hampton used to estimate body fat was different than that used in the present study. The three-named factors may have contributed to the discrepancy in values. Similarily, the findings reported by Drinkwater (15) are lower than those for the Spruce Grove sample. Again , the methods used to estimate body composition differed and consequently may have resulted in the divergent scores.

Correlation of Percent Fat to Physical Work Capacity

The correlations of body fat to Physical Work Capacity in the present study and in previous investigations are presented in Table 4.11. The mean value of percent body fat

Table 4.11

Correlation of Percent Fat to Physical Work Capacity in This and Other Studies

Study	Sex	Age (years)	Correlation
Miller & Blyth (1955)	M	19-28	-0.23
Neill (1968)	F	17-20	-0.41
Spruce Grove (1977)	F	13-16	-0.44

for the Spruce Grove sample was 25.1 ± 5.34 %. The correlation of body fat to physical work capacity (kpm/kg/min) was -0.44. This was a significant correlation ($p \leq 0.01$). The Spruce Grove results correspond closely to the correlation coefficient reported by Neill (30). Although the subjects in the Neill study were slightly older, the correlation of -0.41 was found to be significant at the .05 level. The correlation coefficient obtained by Miller and Blyth (29) was substantially lower than the two previously mentioned investigations. From Miller's results, it would appear that the relationship of percent fat and physical work capacity may be different in a male population.

Multiple Linear Regression to Predict Physical Work Capacity

A multiple linear regression was used to determine which of the independent variables would best predict the dependent variables. The list of the independent variables and the R square values for the linear regression are presented in Tables 4.12 and 4.13. Of the independent variables selected, weight, % fat, and the 12 minute run, in linear combination with the 300 yard run accounted for 41 % of the variability in the PWC 170 (kpm/min) scores. Using all nine variables, the total predictive power was 42 %. Combining the first four variables from Table 4.10, the regression equation to predict PWC 170 (kpm/min) was determined to be:

Table 4.12

R Square Values of Independent Variables With Physical Work Capacity (kpm/min)

Variable	R Square
300 yard	0.15
Weight	0.31
12 Minute Run	0.39
% Fat	0.41
Height	0.42
50 yard	0.42
Shuttle Run	0.42
Long Jump	0.42
Sit-ups	0.42

Table 4.13

R Square Values of Independent Variables With Physical Work Capacity (kpm/kg/min)

Variable	R Square
12 Minute Run	0.32
% Fat	0.37
Long Jump	0.38
Height	0.38
Weight	0.38
Sit-ups	0.39
300 yard	0.39
Flexed Arm Hang	0.39
50 yard	0.39

$$\text{PWC } 170(\text{kpm/min}) = -293.3 - (5.33 \times 300 \text{ yard}) + (7.98 \times \text{weight}) + (369.43 \times 12 \text{ minute run}) - (4.25 \times \% \text{ Fat})$$

The independent variables used in the linear regression to predict PWC 170 (kpm/kg/min) are presented in Table 4.11. With all nine variables, only a total of 39 % of the variabliity of the work capacity scores could be explained.

Of these, percent fat in combination with the 12 minute run accounted for 37 % of the variablity. The regression equation based on the two independent variables is as follows:

$$\text{PWC 170 (kpm/kg/min)} = -0.718 + (7.73 \times \text{12 minute run}) - (0.055 \times \%\ \text{Fat})$$

Although the equation for PWC 170 (kpm/min) appears to be a better predictor by 4 %, it involves the inclusion of two additional variables, the 300 yard run and body weight. However, as only 42 % of the variablity in physical work capacity can be explained, at best, the two regression equations would appear to be of limited use in predicting physical work capacity performance.

CHAPTER V

SUMMARY AND CONCLUSIONS

Summary

It was the purpose of this study to investigate the relationships between three selected measures of physical fitness. The subjects were eighty-seven females who participated in the physical education classes at Spruce Grove Composite High School. Participants performed two trials of the criterion, modified Sjostrand PWC 170 test, the C.A.H.P.E.R. Fitness-Performance tests and the twelve minute walk/run test. In addition, estimates of percent body fat were obtained by four skinfold measurements. The four main hypotheses stated that there would not be a significant correlation between trial one and trial two of the PWC 170 test; that there would not be significant correlations between the six C.A.H.P.E.R. performance items and the PWC 170 results; that there would be no significant correlation between the twelve minute walk/run and PWC 170 test and that there would be no significant correlation between percent fat and the PWC 170 test.

Pearson Product-Moment correlation coefficients were calculated between each of the independent variables and PWC 170 results and tested for significance at the .05 level. There were significant relationships between the two trials of the criterion test, between the twelve minute run and PWC

170 and also between percent fat and work capacity. Five items of the C.A.H.P.E.R. tests showed a significant relationship to PWC 170. A multiple linear regression was calculated to determine the predictive power of the independent variables to the dependent variable. The regression equations were found to be of limited strength.

Conclusions

Within the limitations of the study, the following conclusions appear justified:

1. For female subjects, there was a significant correlation at the .05 level of confidence between:

(a) The first trial and the second trial of the criterion, modified Sjostrand PWC 170 test.

(b) The distance covered in the twelve minute walk/run and the results of the Sjostrand test.

(c) Percent fat and work capacity, as measured by the Sjostrand PWC 170 test.

(d) Five items of the C.A.H.P.E.R. Fitness-Performance test, namely, sit-ups, long jump, flexed arm hang, 50 yard run and the 300 yard run and the results of the Sjostrand test (kpm/kg/min).

2. According to the results of the Sjostrand PWC 170 test and the C.A.H.P.E.R. Fitness-Performance test, the Spruce

Grove sample demonstrated above average physical fitness.

General Conclusions

On the basis of this study, it may be concluded that the PWC 170 test is a reliable measure of work capacity in adolescent females. In addition, it has been shown that either the twelve minute walk/run or the PWC 170 test may be used as a measure of endurance capacity in adolescent females. It may also be concluded that percent body fat and work capacity are significantly related.

Recommendations

1. In situations where equipment and trained personnel are at a minimum, the twelve minute walk/run test may be used to assess physical fitness.

2. Further research should be conducted examining the use of the 9 minute run as a substitute for the 12 minute distance test.

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APPENDIX

A

Sample Data Sheet

NAME ____________________________

AGE _____ HEIGHT _____ WEIGHT ______

Skinfolds

Biceps _______

Triceps _______

Scapula _______

Iliac _______

Total _______ % Fat _______

<u>PWC 170</u>		Test #1		Date:						
Load #1	____	H.R. 1'	____	2'	____	3'	____	4'	____
Revs	____								
Load #2	____	H.R. 5'	____	6'	____	7'	____	8'	____
Revs	____								
Load #3	____	H.R. 9'	____	10'	____	11'	____	12'	____
Revs	____								

PWC 170 _____ Kpm

_____ Kpm 1 Kg.

PWC 170 Test #2 Date:

Load #1	____	H.R.	1' ____		2' ____		3' ____		4' ____
Revs	____								
Load #2	____	H.R.	5' ____		6' ____		7' ____		8' ____
Revs	____								
Load #3	____	H.R.	9' ____		10' ____		11' ____		12' ____
Revs	____								

PWC 170 ______ Kpm

______ Kpm 1 Kg.

<u>C.A.H.P.E.R.</u>	Test #1	Test #2
	Date:	Date:
Speed Sit-ups	____	____
Standing Long Jump	____ ____	____ ____
Shuttle Run	____ ____	____ ____
Flexed Arm Hang	____	____
50-yard Run	____	____
300-yard Run	____	____
<u>12 Min. Walk/Run</u>	#1 ____	____
	#2 ____	____

APPENDIX B

Description of

Skinfold Measurements

Skinfold Measurements

The following is a description of the skinfold measurements according to the method of Durnin and Rahaman (16):

(1) Biceps- over the mid-point of the muscle belly with the arm resting supinated.

(2) Triceps- over the midpoint of the muscle belly, mid-way between the olecranon and the tip of the acromion, with the upper arm hanging vertically.

(3) Subscapular- just below the tip of the inferior angle of the scapula, at an angle of about 45° to the vertical.

(4) Suprailiac- just above the iliac crest in the mid-auxillary line.

At these four sites, the skinfold was pinched up firmly between the thumb and forefinger and pulled away slightly from the underlying tissues before applying the calipers for the measurement. All measurements were taken, with the subject standing upright, on the right side of the body.

APPENDIX C

Description of

C.A.H.P.E.R. Performance Items

C.A.H.P.E.R. Performance Test

In 1966, the Canadian Association for Health, Physical Education and Recreation published the C.A.H.P.E.R. Fitness-Performance Test Manual (23). A sample cf 1,000 young Canadians had been tested and national norms, in the form of percentiles, from their results were tabulated. The following is a description of the test items as outlined in the C.A.H.P.E.R. Fitness-Performance Test Manual (23).

Description of Performance Tests

(1) Speed Sit-Ups- The subject assumes a back lying position on a gym mat, hands interlaced behind the head. The knees are bent and the feet are held flat on the floor by a partner. The subject sits up and touches both elbows to both knees and then returns to the starting position. The movement of sit-up and return is counted as one execution. The total score is the number of complete executions performed in 60 seconds. One trial is allowed.

(2) The Standing Broad Jump- The subject assumes a position with the feet slightly apart and the toes behind the jumping line. Flexing at the hips, knees and ankles, and using the arms as an aid,

the subject jumps as far forward as possible. The measurement is in terms of inches to the nearest inch from the take-off line to the heel of the foot nearest to the take-off line. Suggested take-off angles should be between 30 and 45°. Two valid trials are allowed, the better trial being recorded. If any part of the body touches behind the heels, the jump is considered invalid and a repeat trial allowed.

(3) The Shuttle Run- Lying face down, hands at the sides of the chest, and forehead on a starting line, wearing gym shoes, the subject, on signal, jumps to his feet and runs 30 feet to a second line. Two blocks of wood are placed on this line and the subject is required to pick up one block of wood, return to the starting line, and place this block behind the starting line. He must then return to the second line, pick up the second block of wood, and run back to the finish line. The measurement is in terms of seconds to the nearest tenth of a second from the starting signal until the subject crosses the finish line. A warning signal is given before the starting signal, and two trials with a rest in between are allowed, the better trial being recorded.

(4) Flexed Arm Hang- The subject grasps a horizontal bar six feet from the floor with his palms towards the face and is assisted to pull himself to the bar so that his eyes are level with the bar. The arms are fully flexed. The subject is required to hold himself in the hanging position for as long as possible. The total period of time that the sugject can maintain this exact position is determined to the nearest second. The subject must keep the bridge of his nose at the bar. One trial is allowed. The tester counts the seconds out loud. When the subject's head drops below the level of the bar, the test is terminated.

(5) The 50-Yard Run- The subject assumes a starting crouch. On the starting signal, which is the drop of a flag, the runner sprints the 50-yard distance. The elapsed time from the staring signal to the passage of the runner's chest across the finish line is scored to the nearest tenth of a second. One tester may time two runners on adjacent courses with a split timer.

(6) The 300-Yard Run- Starting from a racing crouch start or a standing position, the subject runs straight up and around a stake marker 50 yards distance, and returns to the starting area, and

completes this circuit three times totalling 300 yards. The elapsed time, from the starting signal to the passage of the runner's chest across the finish line, is scored to the nearest second.

APPENDIX D

Physical Characteristics

Physical Characteristics
Subjects

SUBJECT	AGE (mos)	HEIGHT (cm)	WEIGHT (kg)	% FAT
01	168	151.1	54.5	30.7
02	168	154.4	48.6	29.5
03	156	155.0	45.4	21.9
04	156	148.6	35.9	20.5
05	156	158.7	55.0	28.6
06	156	167.6	59.1	29.1
07	156	148.6	38.9	22.3
08	156	165.8	46.8	21.0
09	156	165.1	45.9	15.8
10	156	153.7	57.3	29.5
11	156	161.9	50.2	26.0
12	156	141.0	38.6	28.5
13	156	168.9	58.9	27.3
14	156	157.5	43.6	22.1
15	156	163.9	45.7	31.4
16	156	156.8	56.1	25.8
17	168	160.0	45.0	15.3
18	156	163.9	54.8	23.6
19	156	158.7	52.3	22.5
20	156	158.7	55.9	29.5
21	156	156.1	51.6	23.8
22	168	166.2	60.0	23.3
23	180	181.8	52.7	30.4
24	156	171.3	56.4	22.1
25	156	165.1	58.3	27.9
26	168	150.0	41.8	18.1
27	156	156.1	60.5	28.3
28	156	165.1	48.6	16.9
29	168	163.9	56.4	22.5
30	156	167.6	65.4	32.5
31	156	156.1	45.4	18.7
32	168	147.2	34.5	16.6
33	156	170.1	68.6	23.8
34	156	157.5	51.8	30.8
35	156	160.0	56.4	21.5
36	156	166.2	58.6	25.0
37	156	160.0	47.7	20.0
38	168	155.5	44.3	22.9
39	168	166.2	55.9	26.2
40	168	155.0	56.3	28.5
41	168	162.5	48.2	25.8
42	168	162.5	53.6	22.1

SUBJECT	AGE (mos)	HEIGHT (cm)	WEIGHT (kg)	% FAT
43	168	176.5	53.6	17.2
44	168	160.0	55.4	24.2
45	168	174.0	55.9	23.3
46	168	146.8	57.7	24.7
47	168	135.2	42.9	19.5
48	168	155.0	74.5	37.0
49	168	158.0	56.8	30.0
50	180	146.8	47.9	25.4
51	180	160.7	54.1	28.5
52	168	158.7	44.1	22.3
53	180	163.9	62.3	27.9
54	180	160.0	55.9	29.7
55	168	165.1	56.4	24.6
56	168	156.1	64.1	32.4
57	180	165.1	61.4	29.7
58	168	166.2	59.5	29.3
59	168	158.7	57.2	26.6
60	168	157.5	54.1	23.8
61	168	171.3	54.5	23.5
62	168	165.8	55.0	16.0
63	168	163.9	45.9	17.5
64	168	167.6	52.3	23.1
65	168	157.5	42.7	20.8
66	180	160.0	63.2	29.5
67	168	167.6	50.9	16.9
68	168	166.8	85.4	39.0
69	168	153.0	65.9	35.0
70	168	165.8	47.3	15.9
71	168	156.1	54.1	26.8
72	168	170.9	68.2	26.0
73	156	163.2	75.9	38.0
74	156	175.2	39.8	20.0
75	156	166.2	52.7	17.2
76	168	167.6	72.3	30.0
77	156	163.2	61.8	33.1
78	156	158.7	49.5	22.7
79	156	160.0	49.5	24.6
80	156	161.3	50.9	24.3
81	168	174.0	55.0	22.1
82	168	158.7	52.7	27.6
83	168	157.5	44.5	20.7
84	180	151.1	43.6	23.1
85	168	165.1	59.1	31.1
86	180	152.2	59.1	26.8
87	168	167.0	57.5	22.3

APPENDIX

E

Raw Data

RAW DATA-SKINFOLD MEASUREMENTS

SUBJECT	BICEPS	TRICEPS	SUB-SCAPULA	SUPRA-ILIAC
01	11.0	17.0	15.0	17.5
02	11.0	18.0	12.0	14.0
03	3.5	13.0	8.0	6.5
04	4.0	10.0	6.0	8.0
05	9.5	14.0	9.0	18.0
06	10.0	22.0	8.0	13.0
07	6.0	13.0	6.5	6.5
08	5.0	12.0	6.5	5.5
09	2.5	6.5	5.0	5.5
10	9.0	15.0	9.0	22.0
11	4.0	10.5	10.0	8.0
12	8.0	15.0	11.0	16.0
13	9.0	15.0	10.0	12.0
14	5.0	9.0	7.5	10.0
15	12.5	13.5	21.0	16.0
16	8.0	20.0	7.0	7.0
17	3.5	5.5	5.0	5.0
18	6.5	14.0	8.0	7.0
19	6.0	15.0	6.5	5.0
20	7.0	12.0	19.0	17.0
21	6.0	13.0	10.0	7.0
22	5.0	14.0	9.0	6.5
23	7.0	20.5	10.0	22.0
24	4.0	14.5	6.0	7.0
25	8.0	17.0	14.0	9.0
26	3.0	8.0	5.5	7.0
27	6.0	18.0	12.0	13.5
28	3.0	6.0	7.0	5.5
29	5.0	10.5	10.0	7.0
30	10.0	23.5	15.0	18.0
31	3.0	10.5	6.0	5.0
32	4.0	10.0	4.0	4.0
33	4.0	12.0	10.0	10.0
34	9.0	21.0	15.0	16.0
35	3.0	14.0	7.0	6.0
36	9.0	14.0	10.0	7.0
37	4.0	9.0	7.5	6.5
38	4.5	12.0	9.0	8.0
39	4.0	16.0	12.0	11.0
40	7.0	18.0	13.0	12.0
41	7.5	14.0	7.0	6.0
42	5.5	13.0	7.0	4.5
43	3.0	8.5	6.0	4.5
44	7.0	14.0	9.0	7.5

SUBJECT	BICEPS	TRICEPS	SUB-SCAPULA	SUPRA-ILIAC
45	8.0	12.0	7.0	7.5
46	7.0	18.0	10.0	14.0
47	2.0	10.5	7.5	6.0
48	17.0	32.0	20.0	20.0
49	13.5	22.0	14.0	8.0
50	7.0	18.0	8.0	8.0
51	7.0	16.0	15.0	12.0
52	4.0	6.5	11.0	11.0
53	9.0	16.0	8.0	15.0
54	10.0	18.0	12.0	16.0
55	6.0	12.0	9.0	11.5
56	16.0	24.0	15.0	12.0
57	8.0	18.0	16.0	14.0
58	9.0	19.0	13.0	13.0
59	9.0	17.0	10.0	8.0
59	9.0	17.0	10.0	8.0
60	6.0	12.0	8.0	10.0
61	7.0	12.0	8.0	8.0
62	3.0	8.0	5.0	4.0
63	2.0	8.0	6.0	6.5
64	4.5	15.0	7.0	7.5
65	3.5	12.0	7.0	6.0
66	1.0	17.0	12.0	16.0
67	3.0	7.0	5.0	6.5
68	18.0	25.0	30.0	28.0
69	11.0	18.0	31.0	16.0
70	2.5	7.0	5.0	5.0
71	7.5	17.0	9.0	11.0
72	6.5	18.0	10.0	8.0
73	15.0	30.0	20.0	30.0
74	3.0	14.0	5.0	5.0
75	3.0	8.0	6.0	5.0
76	7.5	13.0	19.0	18.0
77	12.5	20.0	20.0	18.0
78	5.0	11.0	6.0	11.0
79	6.5	11.5	6.5	14.0
80	4.5	17.0	10.0	6.0
81	4.5	13.0	9.0	5.0
82	7.0	18.0	12.0	10.0
83	3.0	13.0	6.5	6.0
84	5.5	11.5	9.0	8.0
85	10.0	15.0	14.0	23.0
86	8.0	14.0	11.5	11.0
87	6.5	11.5	7.0	7.0

RAW DATA-BICYCLE ERGOMETER TESTS

SUBJECT	BICYCLE TEST#1 H.R.	W.L. (kg)	BICYCLE TEST#2 H.R.	W.L. (kg)
01	123	.5	115	.5
	143	1.5	158	1.5
	167	1.5	158	1.5
02	118	.5	118	.5
	132	1.0	153	1.0
	165	1.5	170	1.5
03	110	.5	115	.5
	135	1.0	149	1.0
	171	1.5	171	1.5
04	135	.5	150	.5
	155	1.0	165	1.0
	173	1.5	173	1.5
05	127	.5	127	.5
	143	1.0	157	1.0
	167	1.5	173	1.5
06	131	.5	128	.5
	146	1.0	145	1.0
	170	1.5	173	1.5
07	129	.5	127	.5
	153	1.0	150	1.0
	175	1.5	176	1.5
08	134	.5	122	.5
	149	1.0	142	1.0
	173	1.5	165	1.5
09	107	.5	118	.5
	122	1.0	132	1.0
	150	1.5	157	1.5
10	95	.5	109	.5
	158	1.0	126	1.0
	175	1.5	178	1.5
11	127	.5	105	.5
	148	1.0	122	1.0
	170	1.5	150	1.5
12	133	.5	142	.5
	159	1.0	167	1.0
	189	1.5	191	1.5
13	128	.5	115	.5
	144	1.0	133	1.0
	168	1.5	159	1.5
14	120	.5	114	.5
	131	1.0	140	1.0
	162	1.5	173	1.5
15	125	.5	125	.5
	145	1.0	146	1.0
	171	1.5	168	1.5

SUBJECT	BICYCLE TEST#1 H.R.	W.L. (kg)	BICYCLE TEST#2 H.R.	W.L. (kg)
16	129	.5	137	.5
	159	1.0	159	1.0
	175	1.5	175	1.5
17	106	.5	132	.5
	117	1.0	149	1.0
	171	2.0	175	2.0
18	125	.5	134	.5
	150	1.0	143	1.0
	167	1.5	168	1.5
19	129	.5	103	.5
	137	1.5	133	1.5
	150	1.5	112	1.5
20	146	.5	110	.5
	151	1.0	129	1.0
	171	1.5	159	1.5
21	124	.5	106	.5
	138	1.0	122	1.0
	157	1.5	149	1.5
22	104	.5	99	.5
	111	1.0	115	1.0
	144	2.0	158	2.0
23	113	1.0	113	1.0
	129	1.5	130	1.5
	155	2.0	158	2.0
24	98	1.0	117	1.0
	107	1.5	134	1.5
	161	2.5	171	2.5
25	127	.5	125	.5
	145	1.0	155	1.0
	173	1.5	173	1.5
26	113	.5	129	.5
	125	1.0	154	1.0
	153	1.5	173	1.5
27	111	.5	115	.5
	125	1.0	134	1.0
	155	1.5	154	1.5
28	118	.5	124	.5
	121	1.0	130	1.0
	141	1.5	153	1.5
29	107	.5	129	.5
	144	1.0	153	1.0
	151	1.5	180	1.5
30	106	.5	129	.5
	116	1.0	138	1.0
	170	2.0	176	2.0

SUBJECT	BICYCLE TEST#1 H.R.	W.L. (kg)	BICYCLE TEST#2 H.R.	W.L. (kg)
31	122	.5	132	.5
	144	1.0	157	1.0
	168	1.5	175	1.5
32	121	.5	121	.5
	142	1.0	144	1.0
	178	1.5	175	1.5
33	110	.5	110	.5
	138	1.0	138	1.0
	182	2.0	182	2.0
34	113	.5	125	.5
	137	1.0	150	1.0
	170	1.5	173	1.5
35	115	.5	132	.5
	129	1.0	142	1.0
	153	1.5	155	1.5
36	118	.5	141	.5
	142	1.0	154	1.0
	176	1.5	180	1.5
37	134	.5	119	.5
	153	1.0	144	1.0
	173	1.5	171	1.5
38	132	.5		
	154	1.0		
	168	1.5		
39	127	.5	149	.5
	145	1.0	163	1.0
	164	1.5	180	1.5
40	122	.5		
	132	1.0		
	162	1.5		
41	122	.5	105	.5
	137	1.0	120	1.0
	161	1.5	150	1.5
42	133	.5	136	.5
	151	1.0	159	1.0
	170	1.5	176	1.5
43	133	.5	124	.5
	149	1.0	145	1.0
	180	1.5	176	1.5
44	150	.5	138	.5
	175	1.0	144	1.0
	180	1.0	175	1.0
45	140	.5	131	.5
	154	1.0	157	1.0
	176	1.5	173	1.5

SUBJECT	BICYCLE TEST#1 H.R.	W.L. (kg)	BICYCLE TEST#2 H.R.	W.L. (kg)
46	102	.5	105	.5
	125	1.0	105	1.0
	157	2.0	165	2.0
47	132	.5	114	.5
	158	1.0	130	1.0
	175	1.5	164	1.5
48	119	.5	123	.5
	131	1.0	141	1.0
	149	1.5	154	1.5
49	131	.5	116	.5
	143	1.0	138	1.0
	165	1.5	165	1.5
50	108	.5	107	.5
	127	1.0	122	1.0
	158	1.5	143	1.5
51	120	.5		
	153	1.0		
	168	1.5		
52	138	.5	128	.5
	159	1.0	128	1.0
	180	1.5	167	1.5
53	133	.5	146	.5
	148	1.0	146	1.0
	164	1.5	165	1.5
54	103	.5	120	.5
	121	1.0	120	1.0
	168	2.0	157	2.0
55	103	.5	119	.5
	144	1.5	135	1.5
	164	2.0	170	2.0
56	132	.5	129	.5
	157	1.0	144	1.0
	180	1.5	184	1.5
57	122	.5	122	.5
	129	1.0	140	1.0
	151	1.5	161	1.5
58	127	.5	100	.5
	143	1.0	115	1.0
	164	1.5	137	1.5
59	125	.5	99	.5
	133	1.0	109	1.0
	165	1.5	129	1.5
60	125	.5	133	.5
	141	1.0	151	1.0
	155	1.5	173	1.5

SUBJECT	BICYCLE TEST#1 H.R.	W.L. (kg)	BICYCLE TEST#2 H.R.	W.L. (kg)
61	112	.5	108	.5
	151	1.5	142	1.5
	167	2.0	164	2.0
62	116	.5		
	154	1.5		
	173	2.0		
63	130	.5	129	.5
	150	1.0	138	1.0
	171	1.5	165	1.5
64	106	.5	133	.5
	122	1.0	155	1.0
	167	2.0	176	2.0
65	149	.5	133	.5
	164	1.0	143	1.0
	180	1.5	164	1.5
66	117	.5	128	.5
	140	1.0	150	1.0
	168	1.5	167	1.5
67	115	.5	113	.5
	129	1.0	124	1.0
	142	1.5	148	1.5
68	135	.5	133	.5
	142	1.0	145	1.0
	165	1.5	165	1.5
69	136	.5	136	.5
	151	1.0	151	1.0
	170	1.5	170	1.5
70	122	.5	128	.5
	129	1.0	138	1.0
	155	1.5	162	1.5
71	122	.5	107	.5
	137	1.0	118	1.0
	159	1.5	142	1.5
72	108	.5	125	.5
	129	1.0	134	1.0
	150	1.5	167	1.5
73	118	.5	120	.5
	133	1.0	129	1.0
	151	1.5	146	1.5
74	119	.5	124	.5
	140	1.0	133	1.0
	164	1.5	157	1.5
75	93	.5	101	.5
	137	1.5	144	1.5
	155	2.0	176	2.0

SUBJECT	BICYCLE TEST#1 H.R.	W.L. (kg)	BICYCLE TEST#2 H.R.	W.L. (kg)
76	141	.5	115	.5
	159	1.0	129	1.0
	171	1.5	158	1.5
77	106	.5	102	.5
	118	1.0	120	1.0
	171	2.0	162	2.0
78	148	.5	149	.5
	176	1.0	173	1.0
	178	1.5	189	1.5
79	112	.5	127	.5
	134	1.0	140	1.0
	158	1.5	168	1.5
80	107	.5	126	.5
	121	1.0	145	1.0
	149	1.5	158	1.5
81	145	.5	115	.5
	158	1.0	142	1.0
	176	1.5	165	1.5
82	134	.5	131	.5
	149	1.0	153	1.0
	171	1.5	173	1.5
83	141	.5	132	.5
	159	1.0	146	1.0
	171	1.5	164	1.5
84	127	.5	122	.5
	145	1.0	140	1.0
	168	1.5	165	1.5
85	122	.5	117	.5
	134	1.0	135	1.0
	159	1.5	167	1.5
86	115	.5	108	.5
	129	1.0	113	1.0
	149	1.5	146	1.5
87	123	.5	118	.5
	132	1.0	133	1.0
	157	1.5	158	1.5

RAW DATA 12 MINUTE RUN

SUBJECT	DISTANCE (miles)	SUBJECT	DISTANCE (miles)
01	1.06	45	1.09
02	1.07	46	1.26
03	1.24	47	1.25
04	1.20	48	.92
05	1.31	49	1.14
06	1.16	50	1.33
07	1.22	51	1.09
08	1.30	52	1.02
09	1.26	53	1.22
10	1.24	54	1.34
11	1.30	55	1.44
12	1.10	56	1.37
13	1.18	57	1.24
14	1.18	58	1.29
15	1.09	59	1.37
16	.84	60	1.37
17	1.23	61	1.22
18	1.30	62	1.46
19	1.28	63	1.26
20	1.19	64	1.23
21	1.24	65	1.15
22	1.41	66	1.03
23	1.25	67	1.48
24	1.23	68	1.04
25	1.06	69	1.12
26	1.16	70	1.29
27	1.17	71	1.30
28	1.56	72	1.21
29	1.23	73	0.0
30	1.03	74	0.0
31	1.18	75	0.0
32	1.41	76	.94
33	1.03	77	1.24
34	1.32	78	1.10
35	1.10	79	0.0
36	1.01	80	1.02
37	1.30	81	0.0
38	1.13	82	0.0
39	.98	83	0.0
40	1.03	84	0.0
41	1.27	85	0.0
42	1.19	86	0.0
43	1.17	87	1.26
44	1.24		

RAW DATA-CAHPER FITNESS PERFORMANCE TEST

SUBJECT	SIT-UPS	LONG JUMP (ins.)	SHUTTLE RUN (secs)	FLEXED ARM HANG (secs)	50 yd. RUN (secs)	300 yd. RUN (secs)
01	30	52.0	12.6	11.2	8.15	73.4
02	32	61.0	12.8	14.0	8.90	76.5
03	30	71.0	11.3	46.0	7.95	71.0
04	40	57.0	12.4	23.1	8.85	71.2
05	34	68.0	11.2	15.0	7.90	64.3
06	33	59.0	13.5	10.5	8.55	75.6
07	42	60.0	12.3	26.0	8.55	69.4
08	36	70.0	11.4	47.0	7.02	62.8
09	32	72.0	11.9	26.5	7.90	67.4
10	45	71.0	10.8	59.0	7.03	69.0
11	44	72.0	10.7	22.0	7.35	64.5
12	38	62.0	12.4	8.5	9.99	83.3
13	35	63.0	12.5	10.6	8.95	73.4
14	35	55.0	11.9	16.0	8.90	71.7
15	37	66.0	12.5	8.0	7.95	69.5
16	37	54.0	11.9	15.0	8.65	71.6
17	33	67.0	13.2	6.5	8.05	68.9
18	40	71.0	11.1	21.0	7.C5	68.0
19	46	66.0	12.4	25.0	7.45	60.9
20	47	69.0	11.5	21.0	7.75	63.4
21	51	54.0	11.0	54.5	7.55	68.1
22	52	75.0	10.9	31.0	7.25	62.5
23	33	65.0	11.9	4.5	7.55	69.7
24	41	63.0	12.2	32.0	8.25	71.5
25	35	70.0	11.7	19.1	8.35	79.0
26	52	75.0	11.2	18.1	7.40	63.7
27	30	67.0	11.7	10.0	8.20	70.2
28	61	77.0	11.8	60.0	6.70	58.7
29	42	64.0	12.3	17.5	8.35	69.2
30	34	63.0	11.8	18.0	8.25	71.5
31	43	74.0	11.1	66.0	7.75	66.2
32	42	57.0	12.3	45.0	8.60	67.9
33	42	59.0	11.8	7.0	8.85	69.0
34	33	60.0	11.5	19.1	8.45	67.9
35	36	75.0	11.1	13.9	7.25	65.5
36	46	74.0	11.8	21.0	8.20	68.9
37	53	80.0	10.3	70.1	7.00	69.0
38	62	75.0	11.5	36.0	8.50	67.3
39	34	45.0	12.0	9.0	8.50	72.8

SUBJECT	SIT-UPS	LONG JUMP (ins.)	SHUTTLE RUN (secs)	FLEXED ARM HANG (secs)	50 yd. RUN (secs)	300 yd. RUN (secs)
40	29	72.0	11.7	33.1	8.60	69.0
41	40	58.0	13.6	24.0	8.10	62.0
42	42	74.0	11.2	62.4	8.00	73.0
43	34	62.0	15.3	4.0	9.00	77.0
44	55	60.0	10.9	23.0	8.00	65.6
45	48	72.0	11.0	30.0	8.25	73.8
46	42	72.0	11.2	30.0	8.25	73.9
47	43	69.0	11.2	30.0	8.60	68.1
48	35	59.0	10.8	7.0	10.00	74.7
49	44	63.0	11.9	19.4	8.50	69.0
50	38	73.0	10.7	34.8	7.90	65.6
51	38	68.0	11.5	21.5	8.10	69.4
52	33	50.0	11.7	6.0	9.70	80.0
53	39	68.0	11.7	6.0	8.65	69.6
54	37	62.0	12.5	12.0	7.75	67.2
55	53	73.0	11.0	33.0	7.55	61.5
56	36	53.0	11.6	5.0	7.35	63.4
57	33	74.0	11.1	13.0	7.75	65.5
58	45	73.0	11.2	38.5	7.40	72.6
59	48	73.0	11.1	42.5	7.35	63.4
60	38	54.0	11.0	24.0	8.05	63.5
61	68	66.0	11.7	32.0	7.95	69.5
62	52	77.0	10.9	38.0	7.25	61.8
63	46	62.0	11.7	52.0	7.35	63.0
64	47	63.0	11.5	15.0	8.00	69.0
65	51	66.0	11.6	34.0	8.45	57.1
66	30	42.0	15.0	00.0	11.05	72.4
67	54	77.0	10.9	70.0	7.00	62.5
68	34	63.0	12.3	1.0	8.75	74.0
69	43	65.0	12.2	15.4	8.35	71.3
70	52	73.0	11.2	50.5	7.75	63.4
71	45	70.0	11.7	20.0	7.70	65.1
72	42	70.0	11.4	15.0	7.75	63.4
73	38	48.0	11.8	7.0	8.75	74.4
86	40	59.0	11.9	46.0	8.00	63.0

APPENDIX F

PWC 170 and PWC 170/kg Scores

PWC 170 and PWC 170/KG Scores

SUBJECT	TEST # 1		TEST # 2	
	PWC 170	PWC 170/kg	PWC 170	PWC 170/kg
01	531.86	9.76	612.08	11.23
02	365.60	7.50	459.20	9.40
03	529.47	11.66	508.60	11.20
04	487.98	13.59	447.70	12.47
05	539.70	9.81	482.70	8.78
06	540.45	9.14	525.08	8.88
07	464.40	11.94	480.40	12.35
08	478.73	10.23	528.47	11.29
09	586.90	12.78	639.50	13.90
10	462.60	8.07	641.70	11.20
11	503.75	10.03	653.71	13.02
12	330.20	8.55	374.10	9.69
13	516.42	8.77	610.74	10.37
14	525.24	12.05	159.02	10.50
15	533.20	11.70	590.40	12.90
16	470.10	8.40	467.00	8.32
17	574.00	12.76	614.70	13.66
18	563.73	10.29	587.72	10.72
19	783.20	14.98	713.22	13.80
20	558.70	9.99	594.66	10.60
21	652.46	12.64	713.33	13.80
22	987.58	16.46	743.55	12.39
23	727.83	13.81	721.20	13.68
24	868.69	15.40	826.97	14.66
25	489.59	8.40	503.48	8.64
26	579.11	13.80	474.59	11.35
27	687.14	11.36	672.59	11.12
28	906.73	18.66	694.62	14.29
29	565.86	10.03	463.69	8.22
30	707.85	10.82	637.59	6.75
31	531.11	11.70	487.37	10.74
32	436.01	12.64	487.55	14.13
33	630.78	9.19	630.78	9.19
34	562.39	10.86	502.66	9.70
35	670.68	11.89	825.34	14.63
36	482.71	8.24	455.65	7.78
37	477.62	10.01	548.65	11.50
38	517.71	11.70	0.0	0.0
39	579.81	10.37	433.64	17.76
40	579.76	10.30	0.0	0.0
41	601.06	12.47	611.05	12.84
42	559.27	10.43	468.45	8.74

SUBJECT	TEST # 1 PWC 170	PWC 170/kg	TEST # 2 PWC 170	PWC 170/kg
43	489.37	9.13	498.71	9.30
44	298.66	5.39	336.37	6.07
45	444.15	7.94	448.15	8.02
46	785.52	13.61	689.99	11.59
47	483.77	11.28	525.56	12.25
48	771.18	10.43	0.0	0.0
49	587.56	10.34	597.25	10.50
50	661.61	13.81	704.66	14.71
51	508.50	9.89	0.0	0.0
52	429.28	9.73	485.04	10.80
53	575.99	9.23	604.88	9.71
54	686.56	12.28	884.94	15.83
55	790.65	14.02	751.22	13.32
56	463.64	7.08	470.48	7.34
57	759.38	12.37	582.52	9.49
58	592.82	9.96	805.91	13.54
59	546.85	9.56	0.0	0.0
60	711.56	13.15	514.70	9.51
61	725.40	13.31	774.30	14.21
62	712.27	12.95	0.0	0.0
63	557.47	12.14	586.62	12.78
64	666.93	12.95	599.44	11.46
65	405.88	9.50	575.79	13.48
66	561.75	8.89	506.70	8.02
67	899.78	17.68	718.98	14.12
68	606.09	7.10	570.76	6.68
69	561.39	8.52	0.0	0.0
70	669.13	14.15	634.10	13.41
71	658.42	12.17	784.04	14.49
72	707.78	10.38	594.19	8.71
73	757.39	9.98	838.47	10.05
74	498.54	12.50	637.20	16.00
75	771.95	14.60	695.30	13.20
76	490.23	6.78	628.33	8.69
77	696.62	11.27	759.61	12.29
78	387.58	7.83	346.18	6.99
79	598.91	12.10	566.39	11.44
80	755.62	14.98	655.61	12.88
81	465.96	8.47	547.91	9.96
82	506.87	9.62	489.22	9.28
83	477.60	10.73	585.72	13.20
84	527.16	10.63	586.92	12.99
85	611.55	10.35	576.46	9.75
86	637.05	10.78	710.60	12.02
87	679.26	11.81	644.65	11.21

APPENDIX G

Analysis of Variance

Analysis of Variance

PWC 170 Test-Retest

Age

Source	S.S.	D.F.	MS	F	P
Age Effect	9.056	2	4.528	0.429	0.653
Subjects Within	8.12965	77	10.558		
Total	822.021	79			

Time

Source	S.S.	D.F.	MS	F	P
Time Effect	0.543	1	0.543	0.338	0.563
Age by Time Effect	2.965	1	1.482	0.921	0.402
Time by Subjects Within	123.906	77			
Total	127.414	79			